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B - THE USEFUL CHARGE

Centre National d'Etudes Spatiales

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B - THE USEFUL CHARGE:

I) Summary description:

1) Satellite-holder cone:

It concerns satellite-holder cone D2. This cone is actually in the course of development in the plan of program D2.

✕ The cone is equipped with a yoyo apparatus as well as a new *type* separation system never utilized.

2) Satellite:

2.1. EOLE vehicle:

It includes:

- a structure
- a gravity gradient system of stabilization (mast + unwinder + ballast + damping apparatus).
- solar sensors + an Albedo permitting restoration of attitude.
- a solar generator

The PEOLE solar generator only has cells on the mobile panels.

- a system of 136 MHz aeriels and the 400 - 462 MHz antenna.
- 44 laser reflectors type Dic divided into 8 groups of 5 (1 at the end of each panel) and a group of 4 at the foot of the 400 MHz antenna.
- the whole of the covering permitting assurance of thermic control of EOLE as well as a radiative covering (the EOLE satellite has an isolated core). It is obvious that for PEOLE, it has been necessary to provide the external coverings, as compensation, the principle of the isolated core has been conserved.

2.2. Power system:

a) Ag/Cd 5 Ah batteries actually in the course of development at the SAFT. These batteries ought to be used for D2 and and EOLE.

b) battery protection system:

We shall use the equipment FR 1 (UVD - OVD)

c) inverters:

- The night converter is that of FR 1
- The two other converters have been developed specially for PEOLE (principal converter: CROUZET)
(reply converter: MATRA)

2.3. Telecommunications system:

a) a receptor - decoder assembly.

We shall use that of FR 1. The number of orders furnished for the decoder not being sufficient, it is necessary to attach to it an order multiplying module whose role is to increase the number of functions being able to be telecommanded. Associated with this module, is "motor command logic" which pilots the motor of the unwinder.

b) a telemeasure assembly + associated transmitter

The two telemeasures FR 1 will be used.

- . The TM 1 in PAM/FM/PM completed by the video command sub-module TM which permits modifying the nature of the output signal of the TM 1 coder (see below the numerous modes of function of the TM 1).

. The TM2, wide band telemeasure, in FM/PM.

2.4. Answerer of the EOIE balloon type answerer

It will be carried out in satellite technology and will be equipped with filters permitting accomplishment of distance measure.

2.5. A magnetometer: for the restoration of attitude.

Utilization of FR1 magnetometer

2.6. Two dependence modules:

a) the H.K. FR-1 module which permits measuring the numerous currents of the power system

$$(I_{GS} \cdot I_{BL} \quad V_{OVD} \rightarrow I_{OVD})$$

b) a EOIE dependence module which contains all the measuring bridges of the thermistors of the satellite.

Remark: This module contains the sub-module "video command TM1" (cf. function of the TM).

2.7. Transposition module:

Assures essentially the commutation, at the moment of the separation of the affected signals at the TM2 during the launch phase with the signals to be transmitted during the orbital phase.

2.8. Pyrotechnic timer module and associated equipment
assuring the functions:

- widening of the yoyos

- separation
- opening of the panels

We shall use the pyrotechnic timer of D2.

II) Block diagram: (See schema)

Comment: (The detailed function of each module will be analysed further).

1) Power system:

- a) the solar generator (that of EOIE lightened: fewer cells) furnishes the energy which is stored in the battery.
 - (SAFT Ni/cd 5 Ah battery).
- b) at the terminals of the battery is found the watch converter. (UVD, FR1 converter) which permanently powers the telecommand system (receiver, decoder, order multiplier).
- c) the system of protection against sub-tension: (UVD, FR1 module) is also connected to the battery posts.

If the battery voltage goes below the level 8.25 V, the power relay of the UVD opens and cuts the power of the principal converter (converter "ON") which follows.

The system having proceeded in UVD, a timer of 10 h is disengaged. The relay will not be reengaged until the end of this lapse of time.

It is also possible, however, to act directly on the UVD relay by telecommand. (It's normally in this way that one cuts or begins the principal converter).

- d) The principal converter powers all the satellite equipment with the exception of the telecommand part and the power stages of the transmitter of the answerer.

The latter are powered by a special converter (answerer-transmitter-converter) which is placed behind the protection system UVD.

The converter is automatically begun by the receiver of the answerer, as will be explained in the answerer section.

- e) The battery is also protected against excess voltage by the OVD FR1 system which prevents battery voltage from exceeding a value above 13.8 V (this value is adjusted as a function of the battery temperature).

The OVD contains two dissipators which, connected directly to the battery terminals, dissipate the excess energy supplied by the solar generator and a command circuit situated in the watch converter module.

- f) the power line passes through the module HK FR1 which permits measuring of the currents at different points (I_{GS} , I_{BL} , V_{OVD}).

2) The telecommand system:

We utilize the FR1 system (receiver and decoder)

The telecommand is of the double ton type (address-execution).

The receiver receives a bearing at 148.980 MHz modulated in amplitude.

The decoder has a capacity of 4 orders.

Should the number of functions to be executed be greater, we

have constructed a "multiplier of orders" module which beginning with combinations of simple orders (at the outlets of the decoder) accomplishes the different desired functions. (These functions will be analysed in detail later in the chapter "different modes of function").

Associated with the multiplier of orders module, is the "motor command logic" module which contains the power system of the motor with its different functions (unwinding-winding-stop) as well as different power relays activated by telecommand.

Remark: On the schema the two modules (X of order and command logic are represented by a single "black box").

3) The telemeasures:

We use the two FR1 telemeasures.

a) TM1 Telemeasure of the type PAM-FM-PM.

The TM1 coder is made up of 3 modules:

- a converter supplying the different voltages used in the coder.
- an input coder
- an output coder

b) TM2 Telemeasure of the type FM-PM.

The TM2 coder possesses 5 inputs (5VCO).

The system contains only one transmitter (1 W transmitter of the TM2 of FR1) which is modulated either by video signals coming from the TM1, or by those from the TM2.

Consequently, one can transmit simultaneously the two telemeasures. The selection between emission of TM1 information or TM2 information is made on the order of the telecommand.

An interrupter placed between the outlet of the TM1 coder and the external modulation inlet of the transmitter (under video command module, situated in the HK PEOPLE module) permits sending or cutting the TM1 modulation.

When one is in TM1 emission, the TM2 coder is not under power and it is begun when one passes to the TM2 emission.

4) The answerer:

It contains 6 modules:

- a) the receiver: contains the HF and MF reception stages of 462 MHz
- b) the phase-lock: contains the VCXO as well as the associated circuits of the phase loop.
- c) the local oscillators: contain the multiplying stages which leaving the VCXO frequency, furnish the different frequencies to be sent to the receiver mixers. Besides, the module contains the timer which delivers different signals to the phase loop (notably the sweeping voltages).

The duplicator assuring the linking of the antenna with the transmitter and the receiver as well as the

uncoupling of these two is also placed in this module.

- d) the transmitter: contains the low power multiplying stages as well as the power stages furnishing in departure 4 W at 400 MHz. The module also contains the converter powering the power stages.
- e) the "video adaptation" module: Using the video phase outlet of the phase loop, this module accomplishes the filtering of the sub-protons f_0 and f_1 .

A modulation index control apparatus is incorporated in this module. (See further).

- f) the "video logic command" module:
 - accomplishes the sequence of video measure beginning with a timepiece furnished by the TM1 coder
 - permits the modulation of the answer transmitter while realizing different orders from telecommand.

5) The magnetometer:

The magnetometer utilized is that of FR1

Its principal function is, in connection with the solar sensors, to permit the restoration of attitude of the satellite.

It also permits, during the launch phase (in association with the TM2), measuring the speed of rotation of the third stage and verifying the ejection of the cap.

6) Dependence module:

- | | |
|---------------------|---|
| a) HK FR1 module | for the measure of the different
power currents |
| b) HK PEOPLE module | contains the measuring bridges of
the SL thermistors |

7) Transposition module:

Assures essentially the commutation at the moment of separation, of the signals affected on the TM2 during the launch phase to the signals to be transmitted during the orbital phase.

8) Pyrotechnic timer module:

We use the D2 timer (as well as its associated equipment:
battery, accelero-contact...)

The module contains a so called timer part which is started when the satellite is still on the ground (by way of the umbilical).

The timer successively disengages the firing bolts permitting, the widening of the yoyo then the separation and finally the opening of the panels.

In case the timer part would not have functioned, it is possible to execute the pyrotechnic orders by telecommand.

In the pyrotechnic module the telecommand and timer parts are independent.

III) The miscellaneous modes of function of the satellite:

We shall examine here the miscellaneous possible modes of function of the satellite.

III.1. There is every reason, first, to distinguish three phases in the life of the satellite.

a) ground phrase

b) launch phase

c) orbital phase

a) ground phase:

- the satellite is on the ramp (or in the laboratory)
- it is attached to the satellite carrying compartment
- the umbilical is attached

b) the launch phase:

Phase which passes from the extraction of the umbilical (at the moment of departure) and the satellite compartment separation (shortly after entry into orbit)

In this phase:

- the satellite is attached to the compartment
- the umbilical is extracted.

c) the orbital phase:

Phase which follows the satellite compartment separation
status signals

Two "status" signals indicate to the satellite the phase in which it is located. These signals are sent towards several types of equipment which should have different functions according to the

phase considered.

a) compartment "status"

- when the compartment is present, the status relay compartment (in the transposition module) compartment is closed. (The return of power from the relay is assured by the compartment).
- after separation, the relay is at rest: position II (return of power from the relay is cut).

The status signal is then from 0 V.

b) umbilical "status"

- When the umbilical is attached ("ground" phase), one can send by means of it an umbilical "status" signal, either on + 5 V, or on 0 V.

It's a question of simulating the two other phases for experiments in this phase.

When one sends + 5 V one simulates the orbital phase

When one sends 0 V one simulates the launch phase

- When the umbilical is extracted (launch and orbital phase) the "umbilical status" voltage is 0 V.

Resume:

"ground" phase

compartment status + 5 V

umbilical status + 5 V orbital phase simulation

0 V launch phase simulation

"launch" phase

compartment status + 5 V

umbilical status 0V

"orbital" phase

compartment status 0 V

umbilical status 0 V

III.2. Modes of function for the diverse phases

We shall begin the analysis by the orbital phase, this phase being the most important, and the function during the others preceeding from it rather simply.

a) Orbital phase

a.I.) The three principal modes

We distinguish three principal modes:

- 1) watch mode
- 2) work mode number 1
- 3) work mode number 2

1) Watch mode

Only the watch converter is powered, therefore, only the telecommand parts (receiver, decoder, order multiplier, and UVD) function.

In this mode no transmitter is on charge: the satellite is silent.

2) Work mode number 1

Here in addition to the watch converter, the principal converter is powered, consequently all the equipment, with the exception of the power part of the transmitter of the answerer, are on charge. It is possible in this mode to run all the anticipated experiments except that concerning the 400 - 460 MHz

answerer.

3) Work mode number 2

The watch and principal converters being always on charge, the converter of the answerer transmitter is powered in turn.

This mode corresponds to the functioning of the whole of the satellite and permits the answerer experiments.

These three modes of function correspond to well determined portions of the orbit.

. Work mode number 2 (answerer experiment):

The satellite is in this mode only when it is in view of KOUROU (and in the case where one wishes to start the answerer transmitter; if not, one is in work mode number 1).

Duration of this mode by orbit: at the maximum 15 minutes.

. Work mode number 1

Between the moment where the satellite disappears from the sky above KOUROU and that where it leaves the sky above ground station CNES, the farthest east. (Here, considering the orbit, it's Brazzaville).

Duration of this mode: on the order of 15 to 20 minutes.

. Watch mode: from the disappearance over Brazzaville until the arrival in view of KOUROU.

Duration: on the order of 70 minutes.

off time

The passage from one mode to the other corresponds to the stopping or starting of a converter.

The starting and stopping of the principal converter (work mode number 1)

is done by order of the telecommand sent from the ground.

The telecommand order acts on the UVD relay.

The beginning of the transmitter answerer converter (passage to work mode number 2) is done automatically on indication of phase loop hitching of the receiver of the answerer.

(When a signal is sent from the ground, the phase loop of the receiver hitches itself and causes a trigger to seesaw which acts on the power relay of the converter).

When there is a disappearance of the incidental signal, the loop is no longer locked and the converter is cut. Thus when the satellite disappears from KOUROU, it automatically returns from mode number 2 to mode number 1.

The sequence is the following:

- arrival in view of KOUROU: the satellite is silent (watch mode) on order of telecommand, the principal converter is started (mode number 1).

If next a signal at 462 MHz is sent from the ground, the receiver of the answerer hooks up and the converter of the answer transmitter is put on charge (mode number 2).

- at disappearance from KOUROU, one automatically returns to mode number 1.
- just before disappearance from the sky above Brazzaville, one sends a satellite stop order, the principal converter is cut and one returns to watch mode.

a-II) Analysis of the numerous possible functions in work mode number 1 and 2

Work modes 1 and 2 correspond to the active modes of the satellite. In these two modes, the satellite should permit the

execution of a certain number of experiments and thus should take diverse configurations which we are now going to analyse.

RECAPTULATION OF THE EXPERIMENTS

The two principal experiments to be accomplished at the time of the orbital phase which dictate the diverse configurations necessary are:

- 1) The stabilization of the satellite.
- 2) The radio liaison experiments "back and forth" "400 - 460 MHz".

1 - Stabilization

It concerns stabilizing the satellite.

It is necessary to be able before stabilization (to accomplish the departure manoeuvre of the mast) and after (to insure the quality of stabilization) to restore the attitude of the satellite.

We used to transmit the data captors (solar sensors and magnetometer) the TMI telemeasure coder (which contains sufficient inlets).

- It is necessary on the other hand to be able to command the stabilization mast unwinding motor; three orders are anticipated:

- . unwinding,
- . winding,
- . stop.

2 - 400 - 460 MHz answerer experiment

Three types of function are anticipated: (They will be analysed in detail in the answerer section)

2.1. EOLE simulation

It concerns verifying the function of the EOLE system (Doppler

measure and distance measure).

The distance measure is piloted by the TM1 coder whose rhythm should be sent to the ground. One transmits the TM1 video to the ground in which one has suppressed the pedestal frequency (this operation is automatically accomplished when one passes to work mode number 2 - by the video command sub-module TM1. The detailed foundation of the whole distance measure system is analysed in the answerer section.

This configuration is called TM1 "Blank Burst".

The UHF wave vehicle with two sub - supporters (which permit distance measure). These sub-supporters which are demodulated by the answerer receiver should pass before remodulating the transmitter in the distance measure video filters. Thus the simulation of the EOLE measures:

- utilization of the TM1,
- TM1 video signal is of the "Blank Burst"
- video answerer passes in the distance measure filters.

2.2. "Multipath" experiment

This experiment should permit evaluation of the effect of the multiple reflections on the precision Doppler measures.

One would like to know the variation of the HF level received by the receiver of the answerer. To do this, one telemeasures the level of the "amplitude detector" associated with the phase loop which is the reflection of the level received. In order to be sensitive to the relatively rapid fluctuations of the inlet level, one telemeasures the indication

of the amplitude detector by way of the TM2 (wide band TM).

In this experiment, the UHF carrier is not modulated and consequently the video part of the answerer is put out of circuit (one opens an interrupter in the video line).

In resume, in the multipath experiment:

- utilization of the TM2,
- video part of the answerer is out of circuit.

2.3. "Transmission of data" experiment

This experiment has as its goal testing the possibility of transmitting data from point A to point B while utilizing a simple amplifier such as the PEOPLE. Consequently, one will modulate the UHF carrier sent from the ground by diverse video signals (PN codes, coded voice, etc....)

The video signals having a spectrum greater than that of the tones utilized for distance measure, it is not possible to utilize the video filtering of the answerer.

In this configuration, the video signal demodulated by the phase loop is directly returned to the modulator of the transmitter.

At the time of this experiment, we will use the TM2.

In resume, in the "transmission of data" experiment:

- utilization of the TM2,
- direct outlet video modulator demodulation liaison with the transmitter.

3 - The other experiments

The other experiments accomplished by the satellite necessitate by themselves no particular mode of function. It is simply necessary,

for the reception of information on the ground, that the telemeasure associated with the considered experiment be connected to the transmitter.

When the analysed experiment uses the TM1, we place ourselves in work mode number 1. This in order that the TM1 video course be the normal course (the ground stations are not equipped to receive the blank burst video (which however contains the information)).

The experiments associated with the TM2 can be indifferently received in mode 1 or 2.

- Experiments associated with the TM1 (in addition to stabilization)

- . Study of thermic control.
- . Inspection of satellite equipment.
- . Conduct of the three groups of thin layer solar cells of the type cds.

- Experiments associated with the TM2

Conduct of the three groups of thin layer solar cells of the type Cdte.

- Dynamic geodesy experiment

It can be done in any configuration of work mode number 1 or 2 (it suffices that the 136 MHz transmitter be on charge).

- Laser experiment

As for this one, it is of course independent from the function of the satellite.

RESUME OF THE DIVERSE CONFIGURATIONS

Mode 1

The transmitter of the answerer is not on charge.

Stabilization

. Inspection of attitude

TM1 normal video (no suppression of the "pedestal" frequency).

. Mast manoeuver

TM1 normal video.

Telecommand system in manoeuver position, that is a possibility of sending TC orders to the motor.

. Other experiments

a) - analysis of thermic control,

- inspection of equipment

- time of conduct of three groups of thin layer solar cells of type cds.

TM1 normal video.

b) - study of the conduct of three groups of thin layer solar cells of type Cdte.

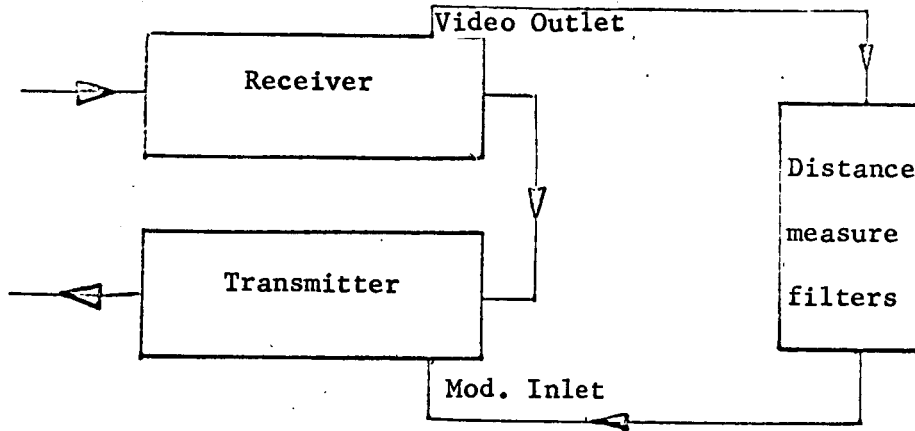
TM2 (can be done also in mode number 2).

Mode 2

The answerer transmitter is on charge (reception of a UHF wave coming from the ground).

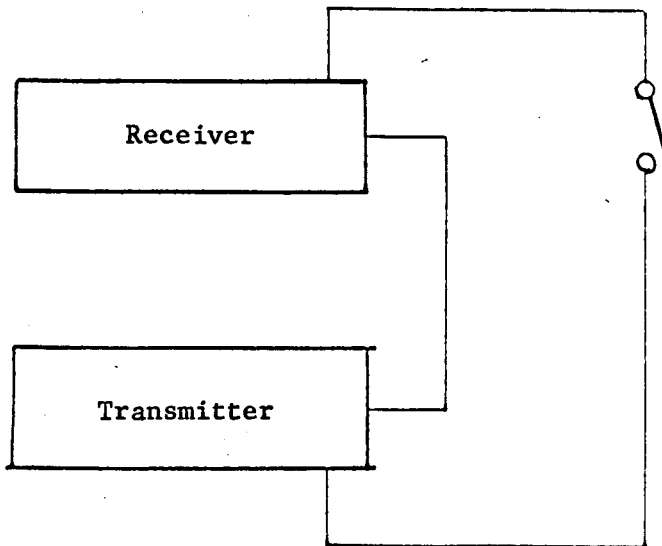
3.1. EOLE experiment simulation

TM1 in "Blank burst"

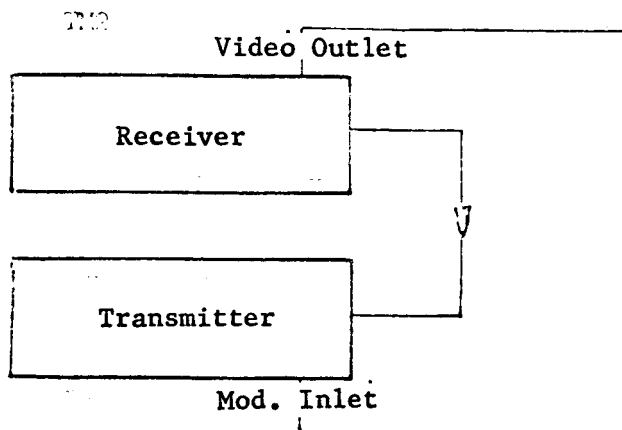


3.2. Multipath experiment

TM2



3.3. "Transmission of data" experiment



REMARK

- The choice of telemeasure on telecommand order as well as choice of the configuration of the video part of the answerer.
The mast manoeuver is also telecommanded, as well as the starting or the stopping of the principal converter (watch mode passage to mode number 1 or
- inversely).
- On the other hand, the passage from mode 1 to mode 2 and the same time that of the "normal" Tm1 video in "blank burst" accomplished by satellite reception of a UHF broadcast coming from the ground.

b) Launch phase

In this phase, the satellite takes a special configuration which is not found again in the orbital phase.

A certain number of functions are automatically blocked in a state given by the status compartment signal (+ 5 V) and the tele-command no longer has any effect on them.

b.1) Operations accomplished during the launch

- Measure of the levels of vibration following two axes by captors placed at the base of the satellite.
- Measure of the magnetic field, following 3 axes, in order to determine
 - . that the speed of rotation of the launcher
 - . ejection of the cap.
- Doppler measure (and distance) by means of the answerer.

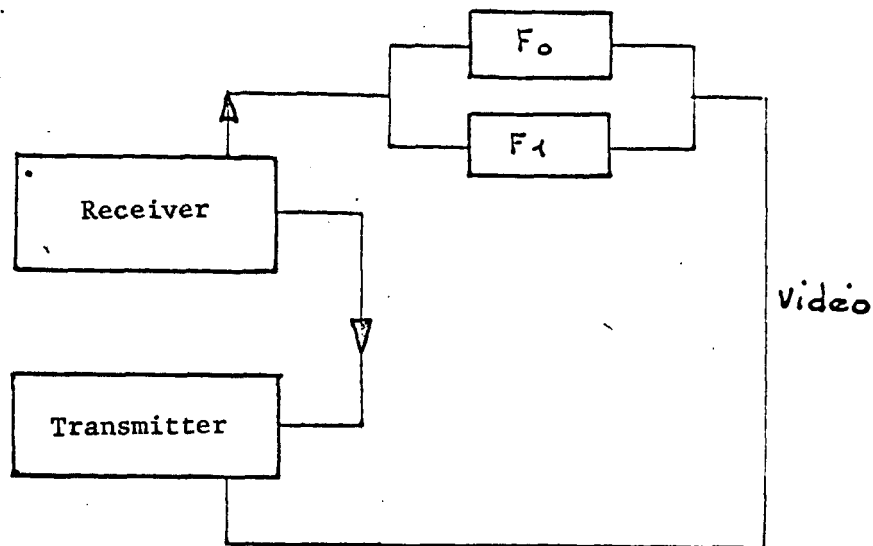
b.11) Configuration of launch

One is automatically blocked in this configuration.

- Utilization of telemeasure number 2.
- The answerer is in EOLE experiment configuration (permits distance measure)

In EOLE simulation experiment, in orbital phase, the two filters Fo and F1 are introduced in the video circuit alternatively or simultaneously according to a rhythm derived from the TM1.

On the other hand during the launch phase, the filters are both permanently in the circuit; in this way one is freed from the synchronization problem (see foundation of distance measure assembly)



b.111) Telecommand in launch phase

The action of the telecommand has been limited to the maximum in this phase.

It is possible simply:

- to stop the satellite (placement in watch mode)
- to start it again (work mode number 1) block in the indicated configuration, then number 2 (after reception of the UHF wave),
- finally, to act on the timer and telecommand parts of the pyrotechnic module.

The first two possibilities correspond to a necessary intervention in case of differed separation from the rocket (the umbilical no longer being connected).

The third corresponds to a possibility of action on the pyrotechnic system in the eventuality of a malfunction of the

programmer.

It is to be noted that if things evolve normally, the telecommand is not used in the launch phase.

c) Ground phase

Corresponds:

- 1) to the test period of the satellite,
- 2) to the period which precedes the launch.

The satellite is on the ramp (or in a laboratory).

The satellite is mounted on the compartment; the umbilical is attached.

c.1) Period of satellite testing on the ramp

During this period, one simulates the two preceding phases with the help of the signal status umbilical:

+ 5 V: orbital phase simulation

0 V: launch phase simulation.

All the functioning configurations of the satellite are analysed.

In this phase, the "pyrotechnic" and "motor command" stoppers are pulled.

The pyrotechnic stopper assures the continuity of the firing electric circuits of the explosive bolts.

The command motor plug permits the powering of the motor (coming from the motor command module).

During the test period, it is possible to verify the proper functioning of the system and in particular the correct arrival of the signals at the level of the plugs.

For the pyrotechnic module, a test connector is provided on which one can attach a test box in this phase. Aside from the tests a "pyrotechnic test plug" is attached to the connector.

Finally, a fourth plug: (power or T.O.P. plug) permits putting the battery in the power circuit.

In this test phase on the ramp, only the TOP plug is in place.

When one passes from the test stage to the launch configuration, it is necessary to put the four plugs in place.

c.11) Period preceeding the launch

REMARK:

The times of the chronology are given simply in the indicative title.

at H - 16 H: placement of the T.O.P. stopper beginning with this moment, one no longer has access to the tower.

The battery is charged by exterior power via the umbilical.

In this phase, it is possible to control the diverse modes of functioning of the satellite (as in the preceeding phase).

at H - 3H30: second phase of armament:

placement of the pyrotechnic and motor command plugs.

The satellite is placed in launch phase configuration (umbilical status OV).

A TC order is no longer sent.

at H - 1 mn: passage of the batteries to "internal".

at H - 44 s: starting of the pyrotechnic timer.

at H - 34 s: passage of the "top 10 sec." of the timer.

c.III) The umbilical

permits:

- the external powering of the satellite:
the charge of the several batteries (principal battery of the satellite and batteries of the pyrotechnic system).
- the command of the satellite:
 - . sending of go-stop order acting on the UVD relay,
 - . sending of the starting and stopping order of the timer,
 - . sending of the umbilical status signal.
- the passage of several indications concerning the functioning of the equipment:
 - . "bus line" voltages,
 - . OVD dissipator voltages,
 - . voltages of the different outlets of the converters,
 - . voltage of the pyrotechnic batteries,
 - . state of several relays,
 - . indication of proper functioning of the pyrotechnic timer,
 - . position of the security relay of the pyrotechnic apparatus.

On the other hand, the umbilical contains a certain number of volume wires:

- volume measure,
- volume power,
- mechanical satellite volume.